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TOMATO GROWING IN CALIFORNIA*

BY STANLEY S. ROGERS

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IMPORTANCE IN CALIFORNIA

Owing to the favorable soil, moisture and climatic conditions for growing tomatoes in many sections of California, the culture of this crop for the canneries, fresh markets and eastern shipments has long been an important industry. During the season of 1914, there were approximately 200 carloads of tomatoes raised in this state for canning, of which 150 carloads came from the southern and 50 carloads from the central and northern portions of California.[1]

The total acreage of tomatoes in California grown for the canneries during 1914 was approximately 10,000 acres and the estimated acreage for 1915, 6,000 acres. Several hundred acres are yearly de-

* Revision of Bulletin No. 239 of this Station.

[1] California Fruit News, December 26, 1914, p. 53.

voted to growing this vegetable for eastern and local fresh markets. The culture of this crop is widely distributed throughout California and there is probably not a county in which it is not grown during some season of the year. The principal counties producing tomatoes in California, however, are Los Angeles, Orange, Alameda, Santa Clara and Sonoma. There is also a considerable acreage throughout certain portions of the San Joaquin and the Sacramento valleys. The production of tomatoes for eastern fall and winter shipments is largely carried on in southern California. Aside from the large acreages above referred to, this crop is very important to the miscellaneous vegetable grower so that it holds a conspicuous place in many of the market and home gardens throughout the state.

YIELD

The average yield per acre of tomatoes grown for the canneries varies from 8 to 10 tons. Under favorable conditions and with proper care, yields of from 15 to 20 tons and occasionally of 25 tons per acre are realized. The average yield obtained when producing tomatoes for the fresh markets varies from 10 to 12 tons per acre, while occasionally 20 to 25 tons per acre are secured.

COST OF PRODUCTION AND PRICES RECEIVED

The cost of producing tomatoes for the canneries varies from $25.00 to $45.00 per acre, the average being $32.00. The cost of raising tomatoes for the fresh markets varies from $35.00 to $50.00 per acre, the average being $40.00. The prices paid by the canneries vary from $6.00 to $8.00 per ton, while the prices paid on the fresh markets vary from $10.00 to $40.00 per ton, the average being about $20.00. The growers often realize more than the figures given above, especially when the crop is matured during the early spring or late fall.

CULTURE REQUIREMENTS

Soil.—Tomatoes are grown on a large variety of soils varying from adobe to sand; the most favorable being largely dependent upon the season of growth and the uses to which the crop is to be put. This crop is better adapted to soils of ordinary quality than many other vegetables, for if the soil contains an over supply of nitrogen, or moisture, the growth of the plants will go to vine at the expense of the crop. If, on the other hand, it is deficient in plant food and moisture, the growth of the plants will be stunted with a consequent lessening of the yield. The most desirable soil for the early spring and late fall crop is a sandy loam, rich in plant food and underlaid

from 3 to 5 feet by a heavier stratum. For the mid-summer and canning crop a medium heavy loam fairly rich in plant food and holding moisture well will be found the most satisfactory. As the tomato is a deep-feeding crop, there should be from 3 to 5 feet of good soil.

Climate.—The tomato is easily injured by cold but will endure heat well provided the soil moisture is optimum. Temperatures varying from 80 to 90 degrees during the day and 60 or 70 degrees during the night are well adapted to the needs of this crop. It is possible in certain sections of the state to grow tomatoes unprotected in the field from February to December, inclusive, but the weather conditions throughout the greater part of California prohibit their cultivation before March and after November.

Moisture.—The moisture requirements of the tomato are moderate but in order that maximum crops may be produced, there should be an adequate amount of moisture throughout the season. If growing during the hot weather the plants should have a larger supply than under cooler conditions. A considerable quantity of tomatoes is grown in California without irrigation, but in producing this crop during the hot summer months and especially in the interior valleys of the state, irrigation is generally practiced. The plants are easily injured by excessive amounts of moisture and hence require good soil drainage, especially during the rainy season.

PREPARATION OF THE SOIL

In the preparation of the field, deep fall-plowing should be practiced where possible. If the soil is of a heavy nature, it may be left in the plowed condition until spring, but on the lighter soils the fields are generally worked down immediately to a good condition of tilth. Unless the soil is very deficient in plant food it is not customary to apply manure or commercial fertilizers previous to planting. When manure is applied, it should be spread on the soil in the fall at the rate of from 5 to 15 tons per acre, plowed under immediately and allowed to rot thoroughly before the plants are set.

A few weeks before planting, the soil may either be replowed, or disced, to a depth of from 8 to 10 inches; the former method being used when the weed growth is luxuriant. After working in the spring, the earth should be brought into as fine a condition of tilth as possible so that at the time of planting all weed growth is checked and a fine mulch is formed. Just previous to planting the field should be marked off to show where the plants are to be located.

GROWING THE PLANTS IN THE SEED BEDS

There are three methods used in California for growing the young plants. Those who produce tomatoes for early spring markets raise their plants in hot-beds, but for the mid-summer and fall crops, cold-frames or open beds may be used. When it is especially desirable to produce early plants, small berry baskets may be placed in the hot-bed filled with earth and the seed planted in them. After the danger from frost has passed and the plants are from six to ten inches tall, the baskets containing the plants may be taken from the beds and set in the field, basket and all, as the baskets will soon decay they will not interfere with the root growth of the plants. Where this method is used several seeds should be sown in every basket and the plants later thinned to one.

The customary method for raising the plants in the seed beds is by sowing the seed in drills from three to six inches apart or by broadcasting. The former method is preferable for the grower who has had a limited experience or for purposes of producing rapidly growing plants. Soil which is used for this purpose should be light in character and worked to a very fine condition of tilth before seeding. It is desirable also to spade under a heavy coating of stable manure long enough in advance of seeding to insure thorough rotting. It will aid in germinating the seed if burlap or muslin be placed on the surface of the ground until the plants have appeared, at which time it should be removed. The seed should be covered with from one quarter to one half inch of soil and it will be found desirable to use sand for this purpose, especially if the soil in the bed is of a heavy nature. The location of the beds should be on a well-drained spot, preferably on the south side of a fence or building. Water should be piped to the beds so that they may be sprinkled with the least effort.

Care of Plants in the Seed Beds.—It is very important that the beds be sprinkled often enough to keep the surface moist, watering frequently rather than putting on larger amounts at longer intervals. Many growers sprinkle their seed beds lightly once or twice a day until the plants have appeared at the surface. Where the surface covering has been used the water may be applied through it. Care should be taken, however, not to have the soil too wet, for the young plants are very susceptible to an over supply of moisture. Where very early plants are desired, the growers sometimes heat the water before applying it. After the seedlings have appeared at the surface, the watering should be done very carefully and consistently. The frequency of watering should be governed entirely by the condition of the plants

and there is more danger from over-irrigation than from putting on an insufficient amount. During cold cloudy weather, the beds should not be watered unless absolutely necessary and the sprinkling should be done preferably on clear mornings, allowing the surface of the soil and the tops of the plants to dry before night.

After the seedlings are from two to four inches in height they should be thinned, leaving a space of from two to five inches between plants. At this time the beds should be carefully weeded and if the seed has been sown in drills, the soil between the rows should be thoroughly stirred. A week or so before the plants are to be taken from the beds, watering should be stopped and if they have been grown under some protection, this should gradually be removed in order that they may become "hardened off," for if the plants are removed when they are growing rapidly, it will be found very difficult to get them established in the field without seriously checking their growth. A few hours before removing the plants, the beds should be thoroughly wet to aid in preserving the fibrous roots that are so important in quickly establishing the plants in the field. If the plants have grown too large, the tops should be cut off to about six or eight inches from the ground before being transplanted.

There are several methods for removing the plants from the beds, but whichever is practiced, care must be taken to remove them in such a way that their root systems are disturbed as little as possible. The experienced grower may be able to remove them from the bed properly by pulling them up by the tops but it is always best to use some implement, such as a shovel or trowel, cutting off the roots about four inches below the surface of the ground and taking as much earth up with the plants as possible. The plants may either be placed in pans or in baskets, or rolled in sacks and carried to the field, care being taken not to expose their roots to the air any longer than is necessary.

PLANTING IN THE FIELD

During the early spring, the soil generally contains sufficient moisture to start the plants without the aid of irrigation, but during the late spring and summer it is customary to irrigate at the time of setting. Where irrigation is necessary furrows from six to eight inches deep are plowed, on the edges of which the plants are set. Water is run in these furrows at the time of planting. Where it is impossible to irrigate by the above named method, the furrows are unnecessary but water should be hauled to the young plants and the earth around every one thoroughly wet.

The holes in which the plants are set should be large enough to accommodate all the roots and after planting the earth should be packed firmly around every plant. These holes may be made by the use of a spade, trowel, dibble or scandigie; the latter implement being especially adapted for this kind of work and used principally by the Italians. The depth to which the plants are set is dependent upon their size and the character and condition of the soil, but they should be planted two to three inches deeper than they were when growing in the seed bed. Deeper planting during the summer than in the early spring is the rule. After the field has been set for a week or ten days, it should be examined carefully and plants set in the spaces in which the original plants failed to start. The distance between the plants varies with the variety, season, character of the soil and the water supply.

When grown for the early spring market, especially if a small vine variety is used, the plants may be set four to six feet apart, in rows six feet apart. The usual distance between the plants when growing the main and canning crop varies from six by six to seven by seven feet.

CULTIVATION

The exact number of cultivations which the field will require depends upon the type of soil, moisture supply, season and the weed growth. As soon as the plants have revived from the transplanting, the field should be hoed and cultivated, care being used not to come too close to the plants. Thorough and persistent cultivation while the plants are small will lessen the cost of production for it is expensive and difficult to cultivate the field after the plants have attained their growth. Under ordinary conditions, the field should be cultivated from four to six times and hand-hoed two or three times during the season. A thorough cultivation should follow every irrigation.

IRRIGATION

In growing tomatoes during the early spring or in certain coast sections at other seasons, irrigation is often unnecessary as the natural amount of soil moisture is sufficient to produce satisfactory crops provided the cultivation is thorough. In the interior valleys and in the southern part of the state, the growers are generally obliged to irrigate their fields when growing tomatoes during the hot dry months. Where this is practiced, the water should be applied often enough so

that the plants are never allowed to suffer from drouth at any time during their growth.

There are two periods when it is undesirable to apply water: (1) Over-irrigation during the time of blossoming will cause the blooms to drop, which materially decreases the yield; (2) if the water is used too late during the growth of the plants, the fruit will be watery, making it unfit for shipment and reducing the quality. As a rule, water is applied soon after transplanting to the field, and a second irrigation is given after the fruit has set. Occasionally one or two more irrigations are necessary from then until the crop has commenced to mature, but it is better to irrigate seldom and cultivate often, rather than to put on the water too frequently. At every irrigation a sufficient amount of water should be applied, so that the soil is thoroughly wet to a depth of from three to five feet, for if small amounts are applied, more frequent irrigations are necessary and the plants will have a tendency to produce a shallow root system which is undesirable. The most common method for applying water is by running it in furrows four to six inches deep between the rows and from one to two feet from the plants. The water should be run down these furrows as slowly as possible, in order that it may penetrate to a considerable depth and the furrows should be cultivated as soon after irrigation as the condition of the soil will permit.

HARVESTING

The method by which the crop is harvested depends largely upon its disposal. For the early spring crop, which is generally sold in the local markets, the tomatoes should be nearly matured before being removed from the vines, and carefully packed in lug boxes or baskets.

When packed for the canneries, the fruit is placed in lug boxes holding approximately thirty-five pounds, and then hauled to the cars or canneries. Tomatoes which are used for this purpose should be matured at the time of harvesting. While this market can use fruit which would be too coarse for the fresh market, the grower should examine the tomatoes very carefully and all wormy, over-ripe, or green tomatoes should be discarded.

When packing for long-distance shipments, the grower should be extremely careful that only fruit of the highest quality is used. After having been picked from the vines, the crop is generally hauled in lug boxes on spring wagons or in wagons in which straw has been placed, to the packing house, where the tomatoes are very carefully wrapped

in tissue paper and re-packed in baskets holding five pounds each; four of which constitute a crate. These are loaded immediately upon cars and shipped to their destination. Fruit which is thus disposed of is generally picked a few days before it has matured.

It is very important that the vines be disturbed as little as possible during harvesting. It is a good plan to pull off all wormy or undesirable tomatoes, as the field is gone over, and to burn these in piles or haul them off the field. Great care should be used in handling the tomatoes, for every bruise may start a rot in a few days, and under no circumstances should the stems be allowed to remain on the fruit.

VARIETIES

During the past few years growers have realized more than ever before that there is a large variation in the yield from individual plants of the same variety. It has, therefore, become customary for the grower to go into his field, picking out the plants which come nearest to his ideal and saving the crop for his future seed supply. It is important in order that this may be efficient, that several seasons be spent in this selection, choosing at every season the vines which are best adapted for one's use. In selecting seed, the grower should consider the whole crop on the vine and not the individual tomato; for the plants which are raised in the future will resemble more closely the entire crop which has been produced on the vine rather than the individual tomato from which the seed was taken. If this selection is carried on carefully, the results in a few years should be superior to those when ordinary seed is used. The varieties which are the most popular in California are the Sparks' Earliana, Stone, Trophy and San Filippo.

Sparks' Earliana.—This is especially popular and highly recommended for the early spring markets for which use it is chiefly grown. The vine growth is not very vigorous and the fruit sunburns. It is not a good shipper, but is well colored, of medium size and round.

Trophy.—Grown chiefly in the San Francisco Bay region for canneries. It is a heavy producer although the fruit will not keep well and is rough.

Stone.—A general favorite on the market. Used throughout California for the local fresh markets, eastern shipping, and canneries. The fruit is highly colored, a good shipper, and excellent in quality. The vine growth is luxuriant and heavy bearing, and the fruit does not sunburn easily.

San Filippo.—Grown chiefly throughout the San Francisco Bay sections and especially in the vicinity of San Jose for the canneries. Is well colored, firm, and a desirable variety.

DISEASES OF THE TOMATO

Damping Off in the Seed Bed.—This disease is mainly troublesome to the young plants and commonly is the cause of large losses. Damping Off is due to several different fungi, the most common being *Rhizoctonia, Fusarium, Botrytis* and *Sclerotinia.* It is mainly troublesome during cold damp weather, especially from the time the plants have come through the surface until they grow to a height of from four to six inches. This disease is characterized at first by the death of a few plants scattered through the seed bed and under favorable conditions these isolated diseased plants will infect the surrounding soil, causing circular diseased areas throughout the bed. An infected plant falls over as if it had been cut off, quickly wilts and dies.

In the control of this disease care should be taken not to use too much water on the surface of the soil and the tops of the plants should be kept as dry as possible. After the disease has appeared, the watering should be stopped until it is necessary to irrigate the plants in order to keep them alive. The bed should be well ventilated and the plants should never be closer than two inches apart. After the disease has appeared, a small trench may be dug around the infected area, which will check its spread to the still healthy plants. Spray with Bordeaux Mixture, using:

Blue Stone	3 pounds
Lump Lime	4 pounds
Water	50 gallons

If the disease is still uncontrollable, the bed should be discarded and a new one started. Soil which has become infected should not be used the following season for growing the young plants, as the fungi concerned are capable of living in the soil a considerable time.

Failure to Set Fruit.—It is very commonly found in California that while the vines set a heavy crop of blossoms, many of the latter fall at the time the tomatoes should be forming. This may be caused by the climatic conditions, such as rain, cold, or heavy fog, extremely dry weather or, in fact, any condition which would prevent proper scattering of the pollen and fertilization of the blossoms. Irrigation at the time the blooms are setting is often responsible for this trouble

and if the growth of the plant is going to vine instead of fruit due to over-richness of the soil in nitrogen, it appears to aid this condition. Occasionally insects eat into the blossoms which injures the latter and makes them useless. For the control of this disease the growers should find out, if possible, which of the foregoing conditions is responsible for the failure of the fruit to set and remedy it as best they can.

Late or Winter Blight.—When growing tomatoes during the rainy season an entire crop is sometimes lost from this disease, but no trouble is occasioned during the dry months, except in a few sections along the coast where there are heavy fogs. The disease attacks all portions of the plant above ground where it causes black lesions to appear. It is caused by the fungus *Phytophthora infestans.* This disease may be controlled by spraying, as soon as it appears, with Bordeaux Mixture made up as follows:

Blue Stone	5 pounds
Lump Lime	6 pounds
Water	50 gallons

Blossom End Rot.—This disease is very commonly found in California and is characterized by the appearance of circular pale yellowish areas at the blossom end. No parasite has been found which is directly responsible for the appearance of this disease, though it may be due to splitting of the skin which allows fungoid and bacterial organisms which later cause the decay to gain entrance. Under California conditions it is found chiefly in sections in which the amount of soil moisture is inadequate or where water has been applied at too irregular intervals. It more commonly appears on plants grown on soils of a light nature.

This disease may be controlled by keeping an optimum amount of moisture in the soil during the entire growth of the plants. Where irrigation is practiced, the water should be put on at regular intervals so that the plants may not suffer for moisture at any time during their growth.

Root Knot.—Occasionally when tomatoes are growing in sandy soil, the vines will suddenly commence to turn yellow, growth stops and they slowly die. Upon examination of the tops of the plants, no unnatural spots on the vines or fruit may be seen, but upon pulling up these vines, the root system will be found to be largely, if not entirely, rotted away and the few remaining roots distorted and decayed. This condition is caused by the nematode worm *Heterodera radicicola.* These minute worms are whitish in color, pear shaped,

about the size of a pin point, and can be seen by cutting into the galls or swellings. The plant is affected in four ways: 1. The water carrying ducts are deranged, making it impossible for food material to pass into the tissues of the plant. 2. The cracks make very good places for bacterial and fungoid organisms to gain entrance and rot the roots. 3. The feeding of the worms upon the tissues of the plant. 4. General weakening of the plant, making it more susceptible to attacks from other organisms.

These worms are capable of living in the soil for an indefinite number of years, provided suitable plants are present for them to live upon. Although the plants may be healthy when set in the field, these parasites, if present, will gain entrance into the roots of the growing plants. Occasionally soil in which seedlings are grown is infected and where this condition prevails, a large percentage of the plants will be diseased while growing in the beds.

The control of the Nematode worm is somewhat problematic and in some cases it has been found exceedingly difficult to eradicate this pest. The following measures of control are recommended: 1. Planting a crop, such as rape or mustard, which is very susceptible to Nematode infection, plowing it up and burning it after the females are in the roots, but before the eggs have had a chance to hatch. 2. Growing crops in the affected fields for a number of years upon which these worms cannot feed, such as corn, sorghums, barley, etc. 3. Thoroughly drying the soil so that the worms may be starved. Where this method is practiced, no crop should be planted. 4. Soil which is to be used for seed beds should be known to be free from Nematode infection. 5. As soon as a plant has become infected, it should be pulled up and the space which it formerly occupied allowed to remain vacant.

Leaf Spot.—This disease is found principally during the early spring while the plants are in the seed beds, and at which time there is considerable moisture in the atmosphere. Throughout the more humid sections of the United States, this disease is more or less troublesome in the field, but owing chiefly to climatic conditions in California it has never been found serious after the plants have been transplanted. It is caused by the fungus *Septoria lycopersici.* Where this trouble appears in the seed bed, the plants should be sprayed with the following mixture:

Blue Stone	3 pounds
Lump Lime	4 pounds
Water	50 gallons

If the disease is troublesome in the field, spray with Bordeaux Mixture made up as follows:

Blue Stone	5 pounds
Lump Lime	6 pounds
Water	50 gallons

Generally one or two sprayings will be sufficient to control this trouble.

Sunburn.—This condition is often troublesome during the hot months, especially through the interior sections of California. Sunburn is characterized by a discoloration of the tomatoes making them unfit for the market. Where this occurs the planting should be done as early in the season as possible and a variety should be used which has a luxuriant vine growth, such as the Stone, in order that the fruit may be protected.

Summer Blight.—This disease is often very troublesome to the growers and during certain seasons is the cause of enormous losses. It is characterized by the dying of individual plants throughout the field, usually after the first hot weather in the spring. A field which is affected by this disease will appear at a distance as if the stand of plants were poor but upon closer examination these apparently vacant spots will be found to contain dead plants.

Upon examining a plant which has recently become affected, the veins of the leaves on the under side will be found to be purple in color. The leaves curl upward, turn yellow and the growth of the plant stops. Upon cutting off the top, the plant will be found to bleed very little, showing a scarcity of sap. During the past few years many experiments have been carried on in order to determine the cause and remedy for this trouble, but so far as known, the direct cause has never been found and only a partial remedy is known. Plants set in the field after June do not become nearly so seriously infected as when planted early in the season.

In a similar disease which occurs in the state of Washington, it has been found that when the seed is planted directly in the field, without transplanting, the trouble is largely avoided. Summer Blight may appear in fields which are growing tomatoes for the first time, and even continuous culture of the crop for a number of years has apparently no effect upon its decrease or increase. Among many varieties tested for their resistance to the blight, there is no striking difference.